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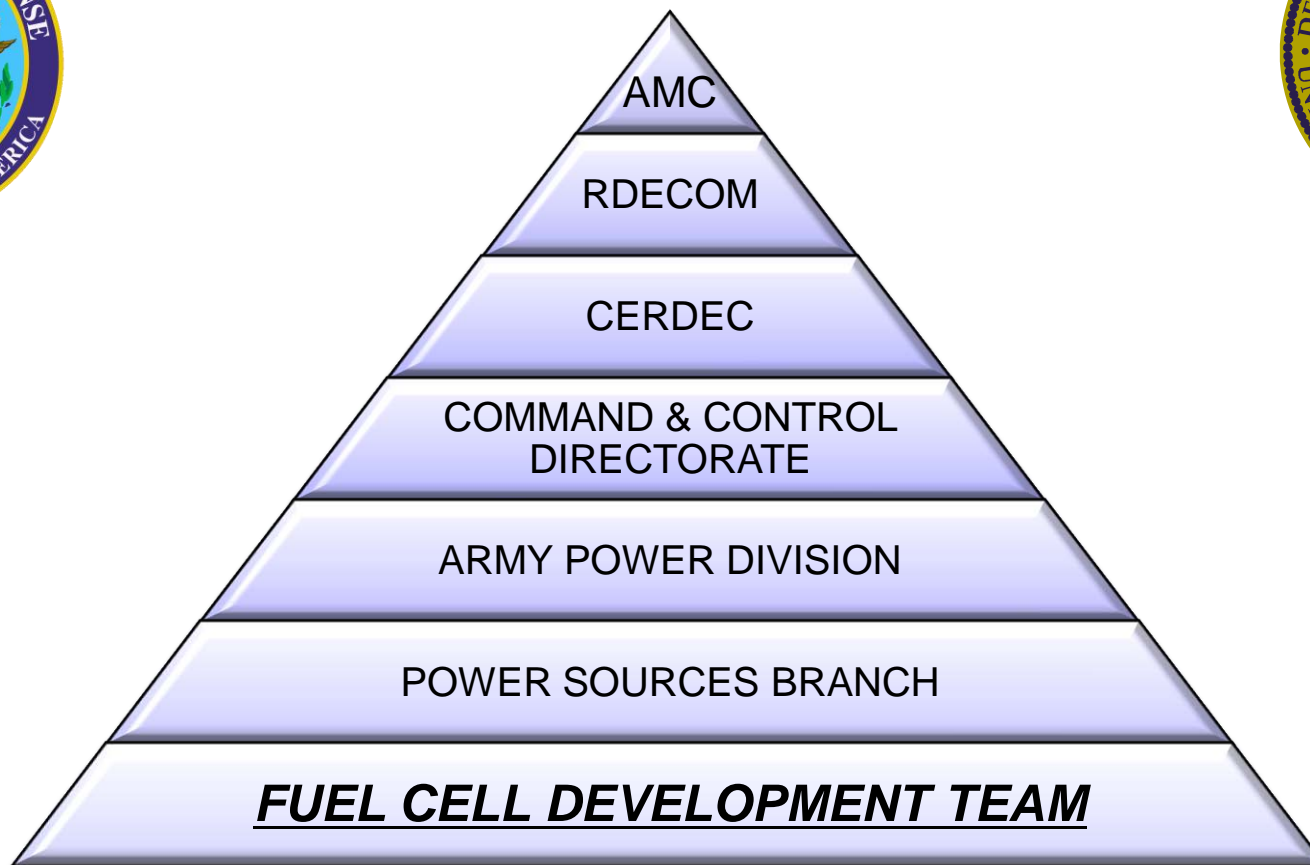
**CERDEC Fuel Cell Team: U.S. Army CERDEC Field Evaluation
and Testing of Soldier and Man-
Portable Fuel Cell Power Sources**

2009 Fuel Cell Seminar & Expo –Palm Springs, CA – 19 Nov 2009
Jonathan Novoa, Shailesh Shah, Marnie de Jong, Mike Dominick, JJ Kowal

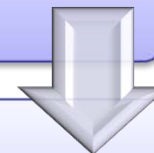
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Department of The Army: Who We Are



Army Power Division & CERDEC Fuel Cell Team Missions



Sensor & Soldier Power

- *Potential Benefits*
- *Recent Test Results*



Man Portable Power

- *Potential Benefits*
- *Recent Test Results*



Demonstrations & Exercises

- *Aberdeen Test Center*
- *Joint Readiness Training Center, Ft. Polk*
- *West Point Military Academy*

To conduct research, development, and system engineering leading to the most cost-effective power, energy, and environmental technologies to support Army's soldier, portable, and mobile applications.

ATOs

ATO R.LG.2009.01 Mobile Power

*Transitional Hybrid Power Source, Log-fueled
Waste Heat Recovery
Power Centric Mobility applications*

ATO D.CER.2008.08

Power for Dismounted Soldier

Half-Sized BA5590 Li/CFx Battery

Half-Sized BA5590 Li-Air Battery

Soldier Conformal Rechargeable Battery

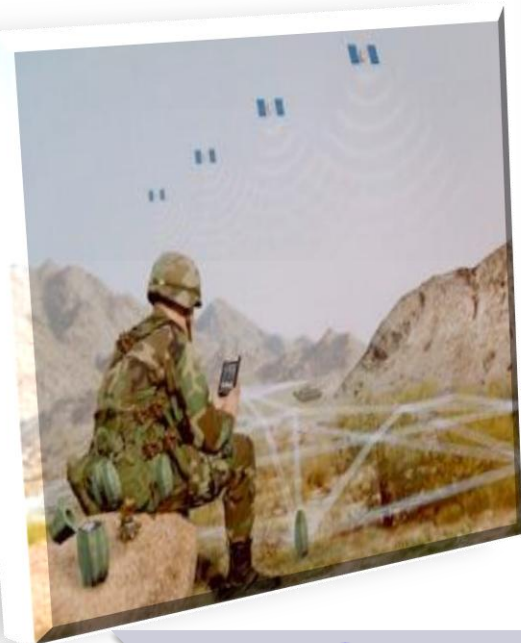
Soldier Hybrid Methanol Fuel Cell Power Source

Soldier Hybrid Fuel Cell Power Source

Portable Hybrid Power Sources & Chargers, JP-8 fueled



To Rapidly Develop & Transition Suitable Fuel Cell Technologies to Applications where they are Most Needed



Sensors
< 5 W



Soldier Power
5 – 100 W



Man Portable
100 – 500 W

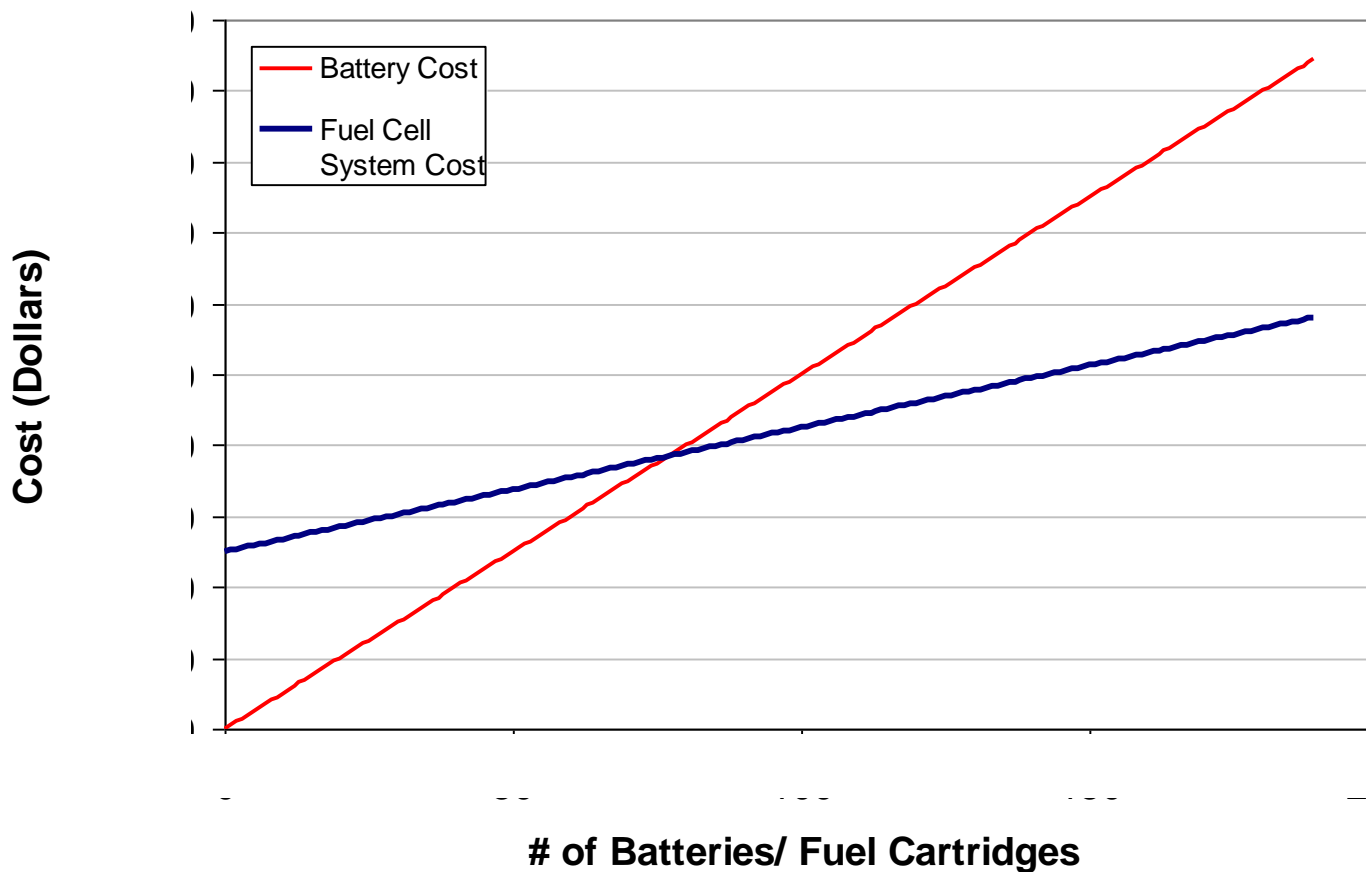
Fuel Cells for Sensor and Soldier Power

Current Programs & Recent Lab Testing Results

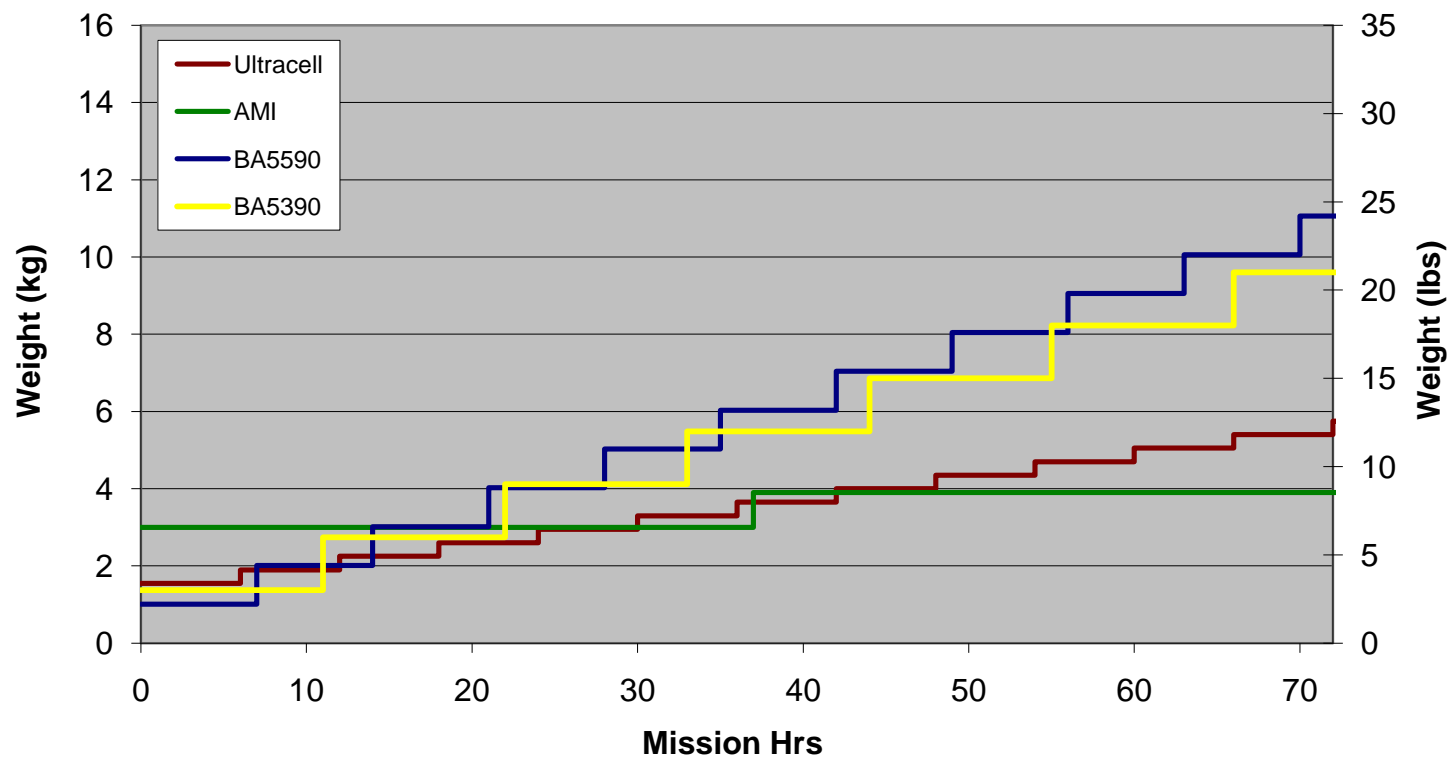


- Longer runtimes than current batteries for comparable form factors
- Logistic advantages related to handling and lifecycle costs
- Cheaper than current batteries for comparable power needs

Cost Comparison for Operating Batteries vs. Fuel Cells

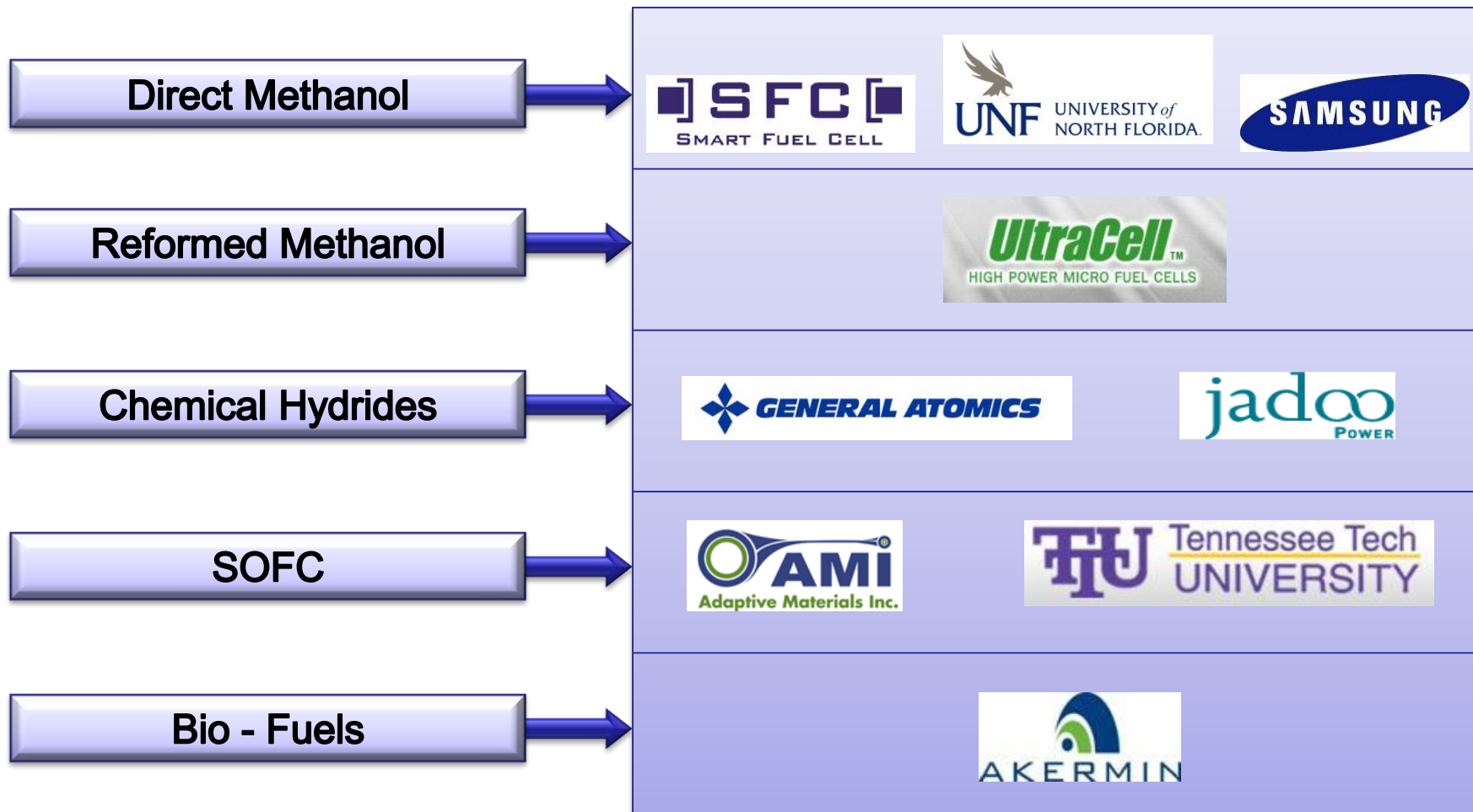


25W Starting Mission Weight vs Mission Hours



Fuel Technology

Current Efforts



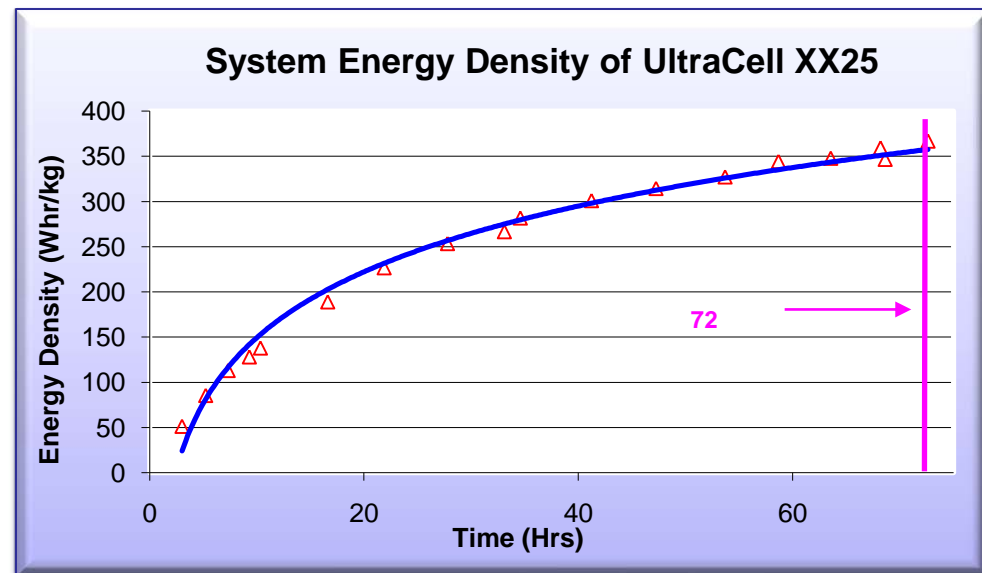
In Development with CERDEC and DARPA

Rated 25W continuous
Reformed Methanol Fuel Cell (RMFC)
Fuel: 67% Methanol / 33% Water

Dimensions: 9.3" x 5.3" x 1.8"
Start Up Time: 20 min.

System Dry Weight: 1.2 kg
Fuel Cartridge Weight: 0.3 kg

25W Mission Energy Density:
24-hr 230 Whr/kg
72-hr 360 Whr/kg



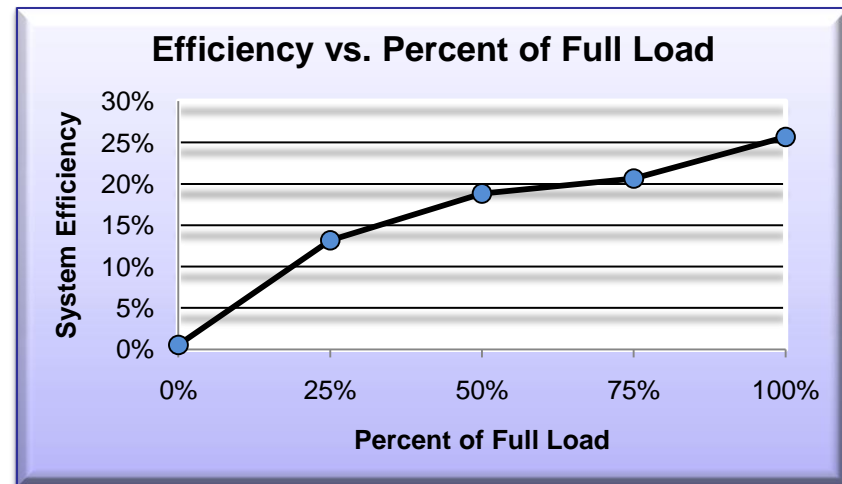
Progression from XX25

Rated 55W continuous (**110W Peak**)
 Reformed Methanol Fuel Cell (RMFC)
 Fuel: 67% Methanol / 33% Water

Dimensions 13" x 8" x 4"
Start Up Time: 25 min / Hybridized

System Dry Weight: 2.7 kg
System Efficiency: 26.0 %

55W Mission Energy Density:
 24 hr 265 Whr/kg*
 72-hr 410 Whr/kg*



* Calculated based on initial data only

Developed with CERDEC and DARPA

Rated 60W continuous (**100 W Peak**)
Solid Oxide Fuel Cell (SOFC)
Fuel: Commercial Propane Canisters

Dimensions: 10.25" x 9" x 4"
Start Up Time: 15min.

System Dry Weight: 2.8 kg
System Efficiency: 18.0 %

60W Mission Energy Density:
24 hr 400 Whr/kg
72-hr 760 Whr/kg



Fuel Cells for Man Portable Power

Current Programs & Recent Lab Testing Results



Auxiliary Power/ Battery Charging

- Bridge power gap between batteries and generators
- Greater efficiencies than TQGs and vehicle power
- Reduced noise and heat signatures
- Enables remote, portable battery charging capability where other power sources are not practical
- Low emissions

Fuel Technology

Current Efforts

Direct Methanol →



Reformed Methanol →



Ammonia Borane →



Sodium Borohydride →



SOFC →



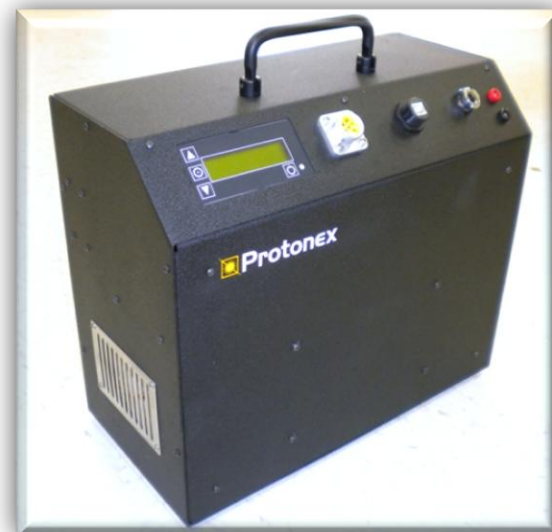
Developed with CERDEC & ARO

Rated 100W continuous
Solid Oxide Fuel Cell (SOFC)
Fuel: 100% Pure Propane

Dimensions: 14" x 6.75" x 3.75"
Start Up Time: 50 minutes

System Dry Weight: 6.9 kg
Fuel Cartridge Weight: 0.8 kg

Fuel Consumption: 38g/hr
System Efficiency: 18.6 %



 **Protonex**TM
The Next Generation of Portable PowerTM

Recent Exercises & Demonstrations

Ballistic Testing:

Determine Fuel Cell and Cartridge Safety
.50 Cal Incendiary Rounds

Targets:

Fuel Cells in Operational Configuration
Propane Canisters
Methanol Cartridges

Results:

Benign Release of Fuel from Containers
No Incident on Fuel Cell Systems



Purpose:

Utilize the UltraCell XX25 RMFC as a Remote Power Source for Dismounted Soldier Applications

Feedback:

*Users enjoy Hotswappable Capabilities
“...Good Mission Extender”*

Environmental Conditions

Temp: 70-100°F

Humidity: 60-100%



Toughbooks



Radios



Charging



Purpose:

Conduct a Human Factors Analysis on the UltraCell XX25 RMFC

Test Factors:

Ergonomics

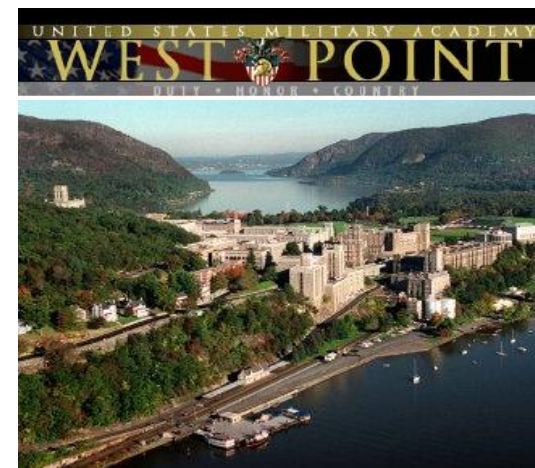
Ease of use

Ability to Read Display (Fuel, Error Codes, etc.)

Testing Results:

Phase 1: August – December 2009 (Classroom)

Phase 2: Summer 2010 (Field Demo)



- Fuel Cells have shown great potential for meeting the increased energy needs of the dismounted soldier
- Many current systems have increased reliability and ruggedness moving from TRL 5/6 to 6/7
- No one technology has shown it will be the sole solution for the military – both fuel and fuel cell need to be safe and user acceptable
- Test and evaluation of fuel cell power systems plays a vital role in assessing the state of technology and transitioning to the procurement stage



Questions?

